RAD
data communications

White Paper

RESILIENT
FAST ETHERNET
RING TECHNOLOGY

Resilient Fast Ethernet Ring Technology

Supports Combined Voice, Legacy Data and LAN Traffic over an Enterprise Metro Area Ethernet Ring

TDMdP
Driven™

November, 2002
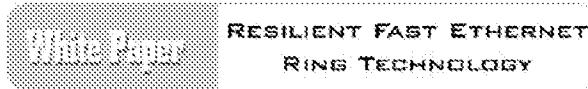
Introduction

Until now enterprises that needed the high speed restoration and high availability of telecommunications service obtainable by ring architectures for distributed networking or Metropolitan Area Networks (MAN) have been faced with a dilemma.

Synchronous Digital Hierarchy and Synchronous Optical NETwork (SDH/SONET) rings undeniably provide a very high level of protection, but synchronous equipment is significantly more expensive than Ethernet-based networking and incurs a heavy bandwidth penalty to achieve its levels of protection. For its part, although it functions well in point-to-point and meshed network topologies, non-trivial obstacles have to be surmounted before Ethernet may be deployed in a ring topology. In particular, SDH/SONET-like fast protection mechanisms are not integral to Ethernet.

An alternative known as Resilient Packet Ring (RPR) combines the resilience of SDH/SONET with the lower cost of IP/Ethernet, but it is not yet widely deployed. Scaled for larger deployments, the industry expectation is that while RPR will become one of the most widely used IP networking tools, it is unlikely to be economically viable for all network sizes and application types.

Now, there is a third approach to low cost, fast restoration networking – Resilient Fast Ethernet Ring (RFER), a new technology that delivers SDH/SONET-type resilience at Ethernet cost for small-to-medium applications.

Lords Of The Ring

One of the most successful modern telecommunications transmission topologies is that of dual fiber optic rings. It's not difficult to appreciate why this topology has become popular. Fiber optic cable provides huge capacity. The ring architecture allows multiple services to be consolidated, transported, inserted and dropped as necessary at end user access points, and the use of dual rings adds intrinsic redundancy, re-routing and reliability. Many applications require the resilience and predictability offered by such rings.

In practice, dual ring topologies have a number of advantages over alternative topologies. These alternatives are meshes, stars, and tree and branch architectures. None of these alternatives offers the same degree of protection as rings and, given the number of links needed to interconnect even modest numbers of access points, all of them can be expensive and challenging to deploy and maintain. The economics of the meshed
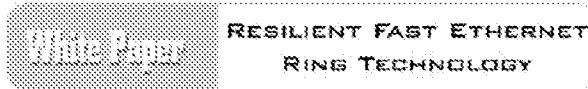
architecture, in particular, do not appear compelling, and are an unlikely candidate for the access network.

The two ring technologies available today are circuit-oriented SDH/SONET, and packet switched RPR. SDH/SONET has a vastly larger installed base.

Benefits of SDH/SONET

SDH/SONET offers a number of benefits for both service providers and end users. It offers impressive bandwidth – work is currently focusing on commercializing STM-256/OC-768 at 40 Gbps; it is highly manageable; and the SDH/SONET protocols are very flexible in payload organization. The two last features are critical since many applications require only relatively small amounts of bandwidth at any one time, so the masses of generated traffic, whether voice, ATM or IP, need to be consolidated and groomed. SDH/SONET, being hierarchical in structure, has the flexibility to efficiently consolidate the lower rate traffic into the thick 'pipes' that constitute the core of the network. SDH/SONET is also a mature, well-understood technology.

Perhaps the strongest selling point of SDH/SONET rings is the high level of service resilience and protection they offer. Even after a fiber cut, the user knows that service will be restored immediately because 50 ms service restoration is inherent in the SDH/SONET restoration mechanisms.

Drawbacks of SDH/SONET

As might be anticipated, there are drawbacks to SDH/SONET ring networks. Having been initially designed for TDM voice, such networks are not optimized for IP LAN traffic.

Another disadvantage is that, despite their ability to manage relatively small amounts of bandwidth, in practice they have poor granularity. Generally only STM-1/OC-3 rates and above are handled, with E1/T1 (VC-12/VC-11) as an absolute minimum.

Furthermore, SDH/SONET ring provisioning can be a lengthy process, and making changes and upgrades to networks made up of more than one ring can be complex.

Of course, cost is a major concern, particularly in the enterprise sector. Ethernet technologies, first 10 Mbps Ethernet, then 100 Mbps Fast Ethernet, and more recently 1,000 Mbps Gigabit Ethernet, offer much lower cost structures as compared to SDH/SONET. Prices for both types of technology are in constant downward flux, but the already considerable gap between the two technologies continues to widen.
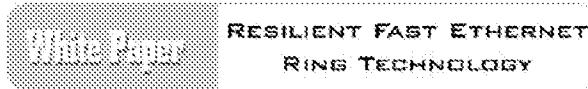
There are also some non-trivial bandwidth utilization concerns. SDH/SONET is not a statistical technology and to exploit the efficiencies of statistical multiplexing mechanisms it is necessary to run Asynchronous Transfer Mode (ATM) on top of SDH/SONET. This can be both cumbersome and expensive.

Finally, it is worthwhile noting that the highly desirable 50 ms restoration time of SDH/SONET is attained at the cost of a 50% bandwidth redundancy, since one of the fibers lies idle until it is called into service to provide the backup.

Ethernet Rings? Pros and Cons

Ethernet surpasses SDH/SONET in making efficient use of bandwidth for data traffic in a point-to-point or meshed topology. The protocol, however, was not originally designed to handle real-time voice and video or for use in ring applications.

Ethernet's built-in recovery mechanisms during a fiber cut are comparatively slow (30 seconds) and not suitable for path level protection, which ensures carrier-class levels of service restoration. Ethernet is also not very efficient at implementing global fairness policies for sharing ring bandwidth.

Resilient Packet Ring

A new approach has been developed to provide the best of SDH/SONET ring restoration with the advantages of Ethernet technology. Dubbed Resilient Packet Ring (RPR), the RPR standard, as well as Cisco's candidate dubbed Dynamic Packet Transfer (DPT), are initiatives intended to provide a full packet based networking solution while achieving the advantages of SDH/SONET rings. Optimized for IP and data traffic, RPR is a statistical networking solution that replicates the efficiencies of the Local Area Network (LAN) in the Metropolitan Area Network (MAN) and Wide Area Network (WAN). RPR/DPT is less complex than ATM over SDH/SONET solutions. It also aims to deliver the sub-50 ms resilience of SDH/SONET rings without the 50% bandwidth overhead.

Ultra-fast RPR/DTP restoration is achieved by running traffic in both directions around the ring all the time. If a break occurs, all traffic is shifted onto one ring. Obviously this risks congestion and service deterioration. To overcome this deficiency, RPR/DPT employs Quality of Service (QoS) mechanisms to give precedence to priority traffic.
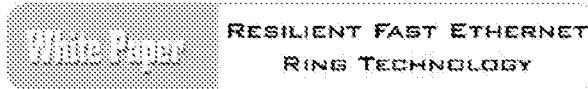
RPR Limitations

But RPR/DPT has its own limitations. The downside of being optimized for LAN and IP traffic is that it is less suitable for voice and legacy data traffic. While end users urgently need the lower costs and increased flexibility offered by Ethernet and IP, most have substantial investments in legacy systems such as PBXs, Frame Relay and ATM. Forklift replacements of these legacy systems are both impractical and too expensive in most instances. Although RPR/DPT equipment may offer reliable transport solutions, they don't have built-in support for access services.

RPR/DPT solutions are also primarily defined and cost-justified for high level, STM-4 and above transport applications. To date there are relatively few RPR chip suppliers and hardware remains expensive.

Lastly, since RPR/DTP endeavors to give precedence to high priority traffic, lower priority traffic may suffer delays. In general there are QoS, latency and recovery issues associated with this approach to service restoration.

Resilient Fast Ethernet Ring (RFER)

Pioneered by RAD Data Communications, a new approach to networking now combines the best features of SDH/SONET and RPR/DTP on fiber or even copper rings. Designed for small-to-medium applications, RFER provides SDH/SONET sub-50 ms restoration performance with improved granularity.

The fast restoration capability of RFER enables users such as enterprises, shopping centers and malls, campuses, utilities and transportation services to create highly reliable networks using dark fiber or dry copper in ring topologies. Ring survivability is further enhanced by RFER's scalable support for multiple rings. This eliminates the risk of a single point of failure.

How It Works

RFER is based on standard, low-cost Ethernet Layer 2 data-link switching with the addition of an intelligent RAD algorithm. It is able to deliver ultra-fast service restoration through its ability to provide each node in a ring with exactly the same, unambiguous view of the status of the network, and so immediately initiate alternate routing if any anomaly or out-of-range condition is detected.
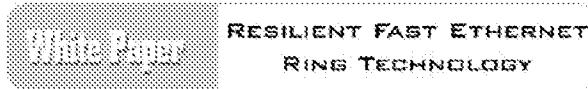
Key Node

An RFER ring node is a network element that functions as a Layer 2 switch. Each RFER node has two ring ports used to carry ring traffic (both traffic that is destined for that particular node and through-traffic destined for other nodes), access ports that load data onto the ring, and user ports to deliver packet services.

When traffic is present, all the RFER nodes exchange point-to-point control messages; each node forwards link state control messages at a given time interval through its two ring ports. Even if there are no ring messages, the port will continue to send 'keep-alive' messages. When a node receives a control message from a port, with an indication that its neighbor is also receiving control messages, the link and the ring are deemed to be functioning correctly. The link is considered 'down' when there is a notification of physical link breakage, a control message doesn't appear within 30 ms, or if a control message is received with a failure indication. Traffic is then sent in the opposite way around the ring.

This arrangement preserves the speed and simplicity of Layer 2 switching, adds fast restoration, and is highly cost-effective to implement in corporate, campus and utility networks.

Access and Service Breakout in One Device

Another notable feature of the RFER solution is the nature of its support for daisy chain networks. In conventional daisy chain networks, E1 or E3 circuits are shared for the length of the chain. Since there is 100 Mbps of capacity available on every Ethernet link between any two sites, and traffic is passed in the switch layer, there is complete flexibility of connectivity between any nodes as long as 100 Mbps is not exceeded on any one link between two sites. (Note: RFER does not work over IP clouds.) Additionally, any daisy chain can be closed to form a ring and so reap the resilience benefits described above.

Contributing significantly to the cost-effectiveness of the RFER solution is the fact that access and service breakout functions are supplied in one low-cost device, the Megaplex access multiplexer. Unlike the E1/T1 minimum of SDH/SONET, the Megaplex handles DS0 and below to support a variety of data and voice services. By contrast, SDH/SONET rings require a separate access device to be able to offer such services. There are also 'hidden' costs relating to the management of SDH/SONET rings that do not appear in RFER.
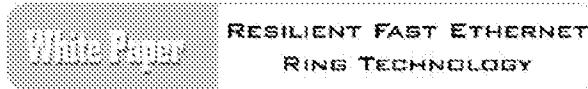
TDMoIP and RFER: Legacy Services over Fast Ethernet with SDH/SONET Reliability

The support of RAD's pioneering Time Division Multiplexing over Internet Protocol (TDMoIP) technology in the Megaplex multiplexer with ML-IP uplink is an essential ingredient in the comprehensive service package. The ML-IP is a three-port 10/100BaseT Ethernet module with up to 4 Mbps uplink capacity. This module serves as the main link to the IP network, placing the packetized TDM data stream from the I/O modules onto the IP network in the form of TDMoIP framing. This integrated technology enables the Megaplex to offer Ethernet simplicity and SDH/SONET reliability. This technology permits the transparent extension of E1/T1 circuits – voice, video, and TDM data – over IP. TDMoIP conceptually operates by chopping the synchronous TDM E1/T1 bit streams into packets, adding IP headers to the packets, and forwarding the packets over the IP network. At the destination, the originating bit stream is reconstructed by removing the IP headers, concatenating the packets, and regenerating the TDM clock synchronization.

Independent Lab Findings

Independent tests performed by the Berlin-based European Advanced Networking Test Center (EANTC) in July 2002 evaluated in detail the forwarding of voice and data traffic in parallel over the Ethernet ring infrastructure implemented with the Megaplex ML-IP. According to the EANTC, "The Megaplex ML-IP passed all tests in three test areas. The ring showed superb service resilience and quality for voice connections. When tested for voice quality, the ML-IP managed to preserve the best possible quality…regardless of the ring network load. In addition, the Ethernet/IP performance evaluation proved the Megaplex ML-IP is ready for the enterprise Metropolitan Area Network."

Since there is no compression and no silence suppression, the quality of the delivered voice is comparable to that of a PSTN connection, provided there is not much delay variation and packet loss. An independent Mier Communications Lab test published in the September issue 2001 of *Business Communications Review* showed that RAD Data Communications' TDMoIP Gateways were found to have superior voice quality, with lower latency and a better price than leading VoIP Gateways. According to the report, "… the high fidelity PCM encoding that RAD's TDMoIP uses, coupled with very low latency, yields superb voice quality." In addition, the testing team stated that " … in our real-time, interactive voice quality tests, as well as the off-line, blind panel ratings of recorded voice samples, RAD…products earned the highest quality ratings. Indeed, all of its scores
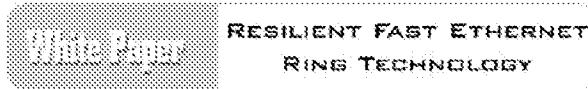
were perfect 5.0s - meaning the quality was indistinguishable from an excellent PSTN phone connection."

Winning Combination: RFER and the ML-IP Ring

The combination of RFER fiber rings and TDMoIP supports some interesting service options. The Megaplex ML-IP can automatically give the highest priority to TDMoIP traffic, even in the event that an increasing amount of IP router traffic is loaded onto the RFER network (via the Megaplex's serial interface or LAN modules). Multiple 'closed' Ethernet/IP rings can actually be interconnected at the TDM level, giving a distributed network topology and extremely high service survivability.

Combining TDMoIP and RFER creates a TDM ring with resilience and capacity similar to STM-1/OC-3. With the addition of the new ML-IP module and fiber optic LAN interfaces, the Megaplex platform can run circuit-switched and packet-switched services on the same infrastructure. The common infrastructure is an Ethernet LAN/MAN. Having one network that is able to support TDM and Ethernet also significantly reduces purchase, maintenance and operating costs.
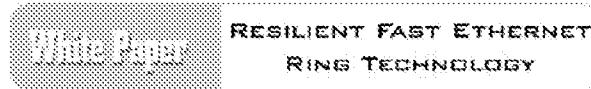
Typical Megaplex ML-IP Applications with RFER

The Megaplex ML-IP multiservice access platform, incorporating TDMoIP and RFER technologies, is an ideal solution for architecting high quality, resilient Fast Ethernet ring structures capable of supporting combined voice, legacy data and LAN metro area network enterprise traffic.

The following slides show typical ML-IP RFER applications:

Ethernet Campus Application

In this scenario, low speed data, legacy voice and IP devices are connected to the RFER. The devices can be daisy-chained behind the ML-IP and incoming/outgoing traffic can be from/to the PSTN and ISPs. This is an extremely cost-effective solution because the access and service breakdown capabilities are contained in a single Megaplex access unit. The TDM ring with native Ethernet offers an extremely high profile self-healing capability. This application applies to any campus network, to utility and transportation companies, and to any entity owning its own dark fiber infrastructure.
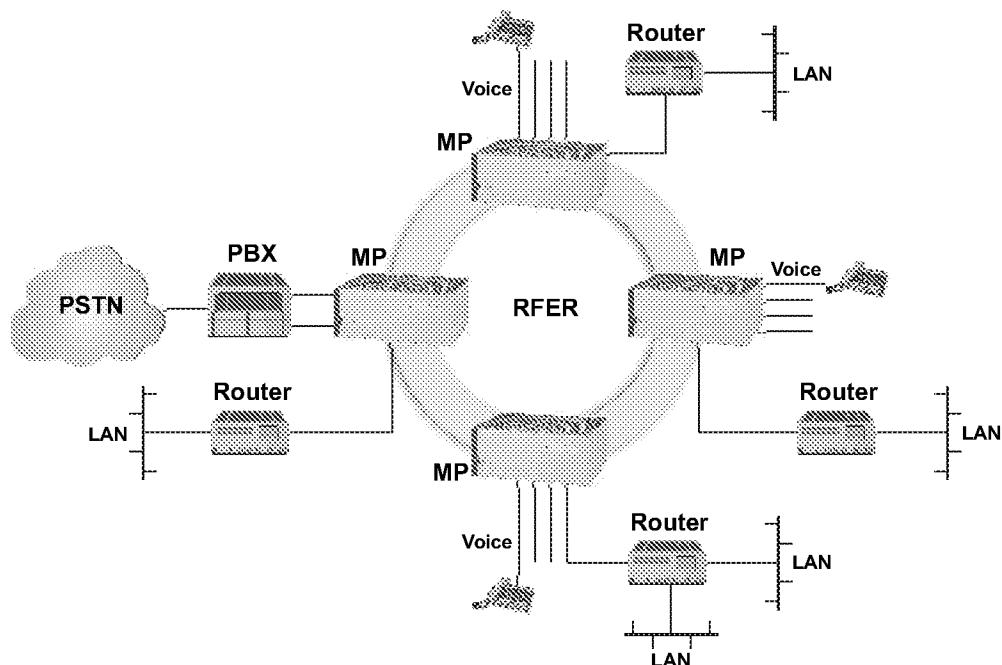
Ethernet Campus Application Using Megaplex ML-IP
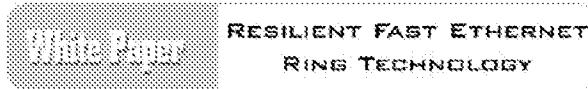
RFER Ring and Daisy-Chain Application

Any number of Megaplex multiplexers can be daisy-chained over a wide variety of interfaces. Any node can be connected to any other node, as long as the effective bandwidth does not exceed 100 Mbps capacity. The Megaplex units loaded with the ML-IP TDMoIP module transports legacy services over the Ethernet network.
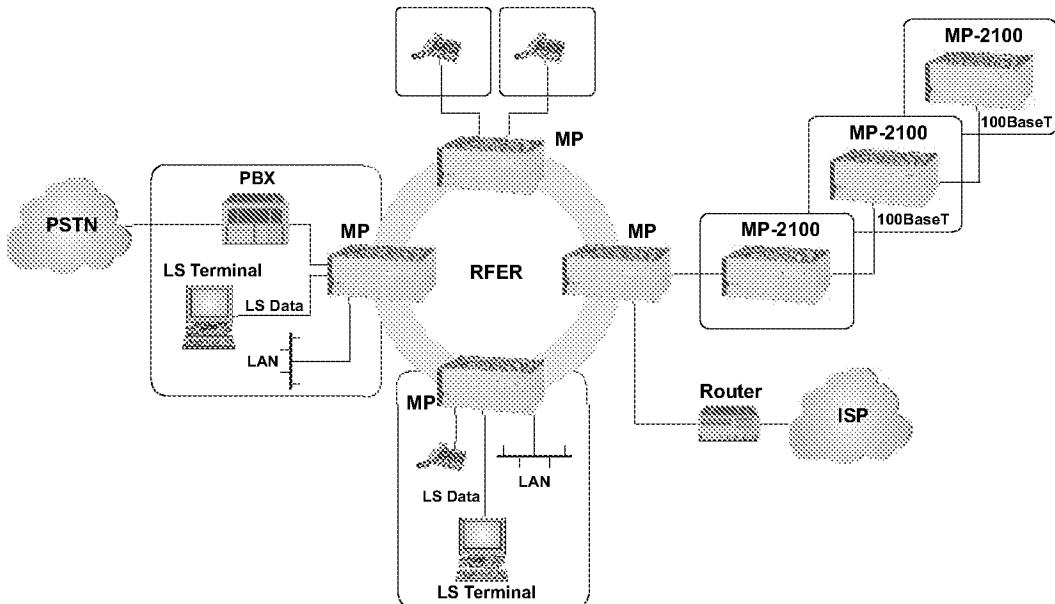
RFER Ring and Daisy-Chain Application

RFER Point-to-Multipoint Applications

In this application, the campus RFER voice traffic is multiplexed as n x E1 and handed over to a conventional SDH/SONET ring for forwarding to a main PBX and subsequently the PSTN. This arrangement extends the resilience or ring architectures into the point-to-multipoint domain and minimizes the number of independent connections needed to access the PSTN.
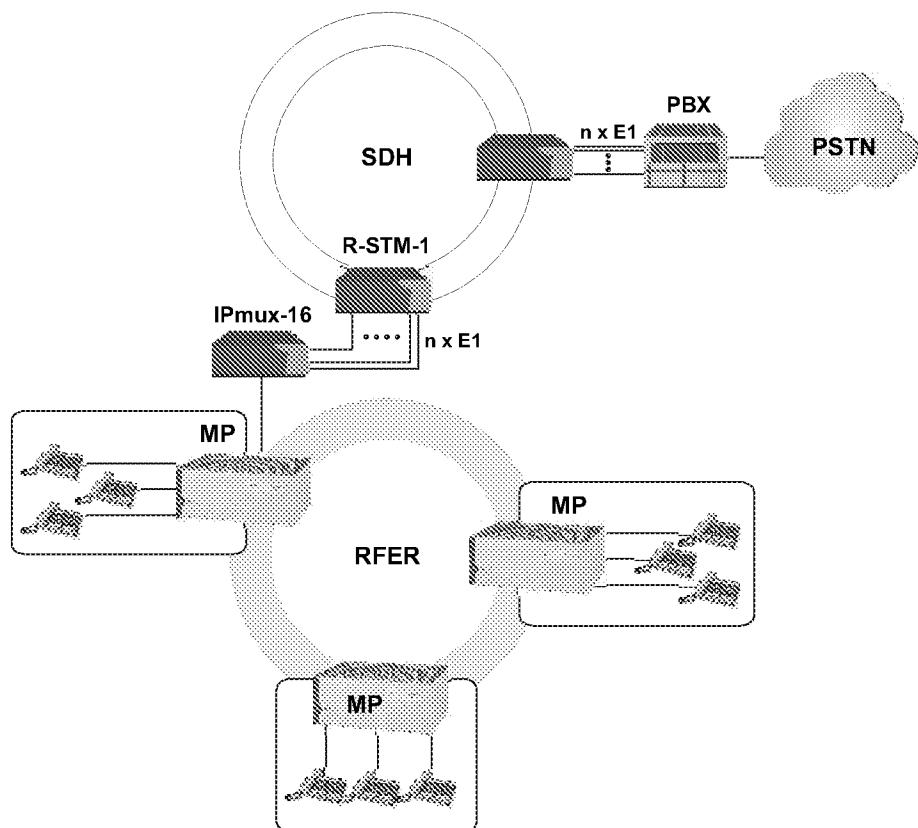
ML-IP with Point-to-Multipoint Application and Interoperability with SDH/SONET Rings
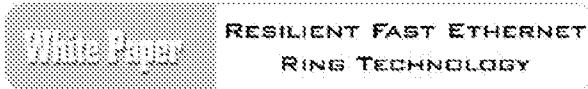
RFER in Utility Environment

In this application, low speed data from sensors and alarm equipment are mixed with video surveillance traffic, LAN and voice over the RFER infrastructure. The platform enables drop-and-insert anywhere in the ring. The Megaplex ML-IP ring solution provides resiliency and link connection protection.
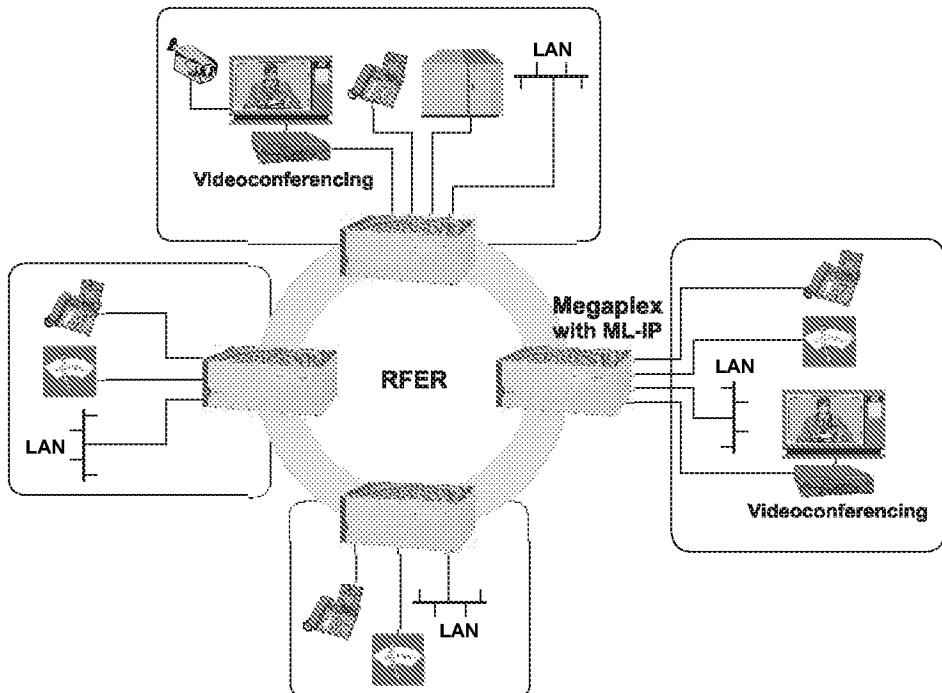
Resilient Fast Ethernet Ring (RFER) for Voice, SCADA, Video and LAN Applications

About RAD

Established in 1981, privately owned RAD Data Communications (www.rad.com) has achieved international recognition as a major manufacturer of high quality access equipment for data communications and telecommunications applications. These solutions serve the data and voice access requirements of service providers, incumbent and new carriers, and enterprise networks, by reducing infrastructure investment costs while boosting competitiveness and profitability. The company's installed base exceeds 4,000,000 units and includes more than 150 carriers and operators around the world. These customers are supported by 18 RAD offices and more than 200 distributors in 105 countries.

RAD is a member of the RAD Group of companies, a world leader in networking and internetworking product solutions.